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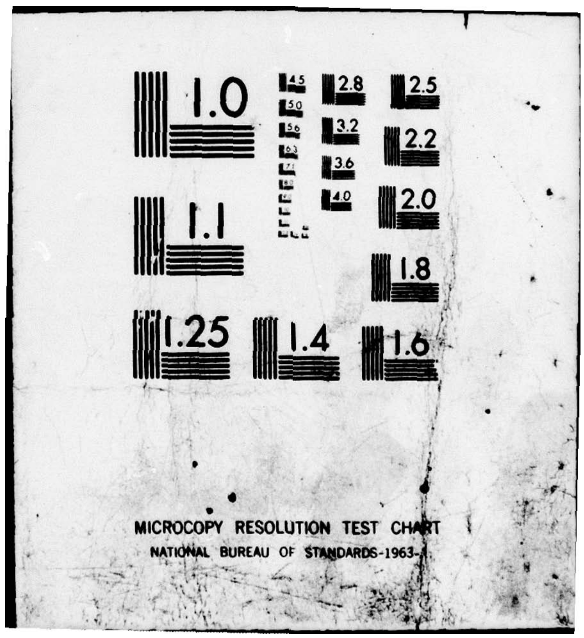
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Operation TEAPOT

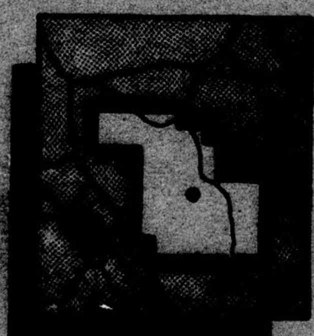
NEVADA TEST SITE

February – May 1955

Project 30.1

MEASUREMENT OF OFF-SITE FALL-OUT BY AUTOMATIC MONITORING STATIONS

Issuance Date: June 26, 1957



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WT-1186

Report to the Test Director

MEASUREMENT OF OFF-SITE FALL-OUT BY AUTOMATIC MONITORING STATIONS

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Health and Safety Laboratory
New York Operations Office
U. S. Atomic Energy Commission
December 1956

ABSTRACT

Unattended, automatic, continuously recording gamma-ray monitors were placed in 28 towns in populated areas adjacent to the Nevada Test Site throughout Operation Teapot. Readings no higher than 10 mr/hr were detected at these locations.

No large quantities of fall-out were encountered. However, the continuous recording of the gamma radiation was compiled at each station. The equipment was reliable and operated unattended over relatively long periods.

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CHAPTER 1

OPERATIONAL PROGRAM

1.1 INTRODUCTION

The problem of determining and limiting the amount of radiation exposure people may receive from bomb debris fall-out has been a subject of concern to the Atomic Energy Commission. From the inception of the continental tests, various methods of locating and measuring fall-out have been utilized. One of the most reliable procedures of documenting an average dosage of a locality has utilized fixed stations with a continuous recording made of the change in the gamma-radiation level. Small changes are measured above background level by using monitors with good sensitivity.

It is necessary to provide good hermetic sealing to prevent intrusion of moisture, to assure constancy of reading with temperature fluctuations, and to minimize the effects of the variable power-line voltage and frequency. The detector was designed to give an approximate air equivalence to permit roentgen dosage readings. Difficulties of field servicing and the need to keep service personnel at a minimum made it necessary to use simple circuits to reduce maintenance operations.

During installation care was taken to place the detector out in the open or on top of the roof so that the element would not be shadowed by rocks, buildings, etc., and it would therefore provide a more characteristic view of the fall-out. The detector is not directional and has good low-energy response.

1.2 OBJECTIVES

The objectives of this program included:

1. Documentation of the changes over background radiation prior to, during, and continuing beyond the actual test period.

2. Field tests and evaluation of the instrumentation with a view toward use during the forthcoming Pacific tests on islands within the range of the fall-out of the larger devices.

3. Tests of telemeter arrays which transmit intelligence by telephone lines, radio telephone, or MCW type radio equipment.

1.3 STATION INSTALLATION

Twenty-eight sites were provided with continuously monitoring gamma-ray detector stations in accordance with the placement shown in Fig. 1.1. The equipment (Figs. 1.2 and 1.3) required a minimum of installation and was acceptable to persons in whose homes and places

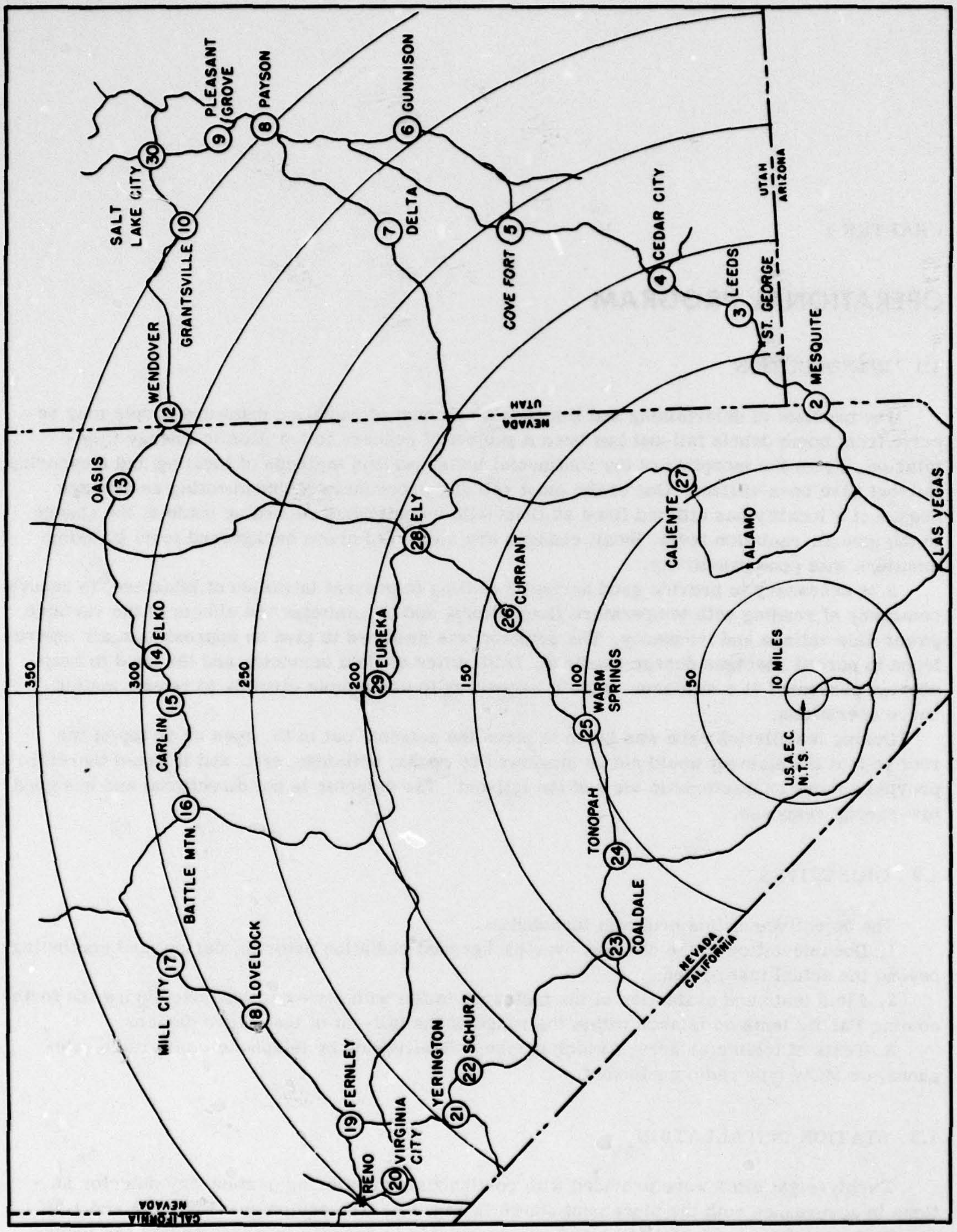

Fig. 1.1—Locations of detector stations.

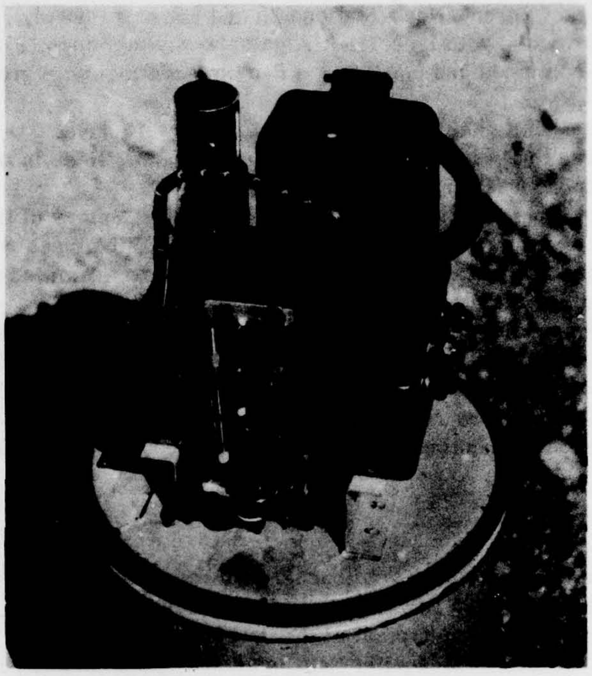

Fig. 1.2—Gamma monitor.

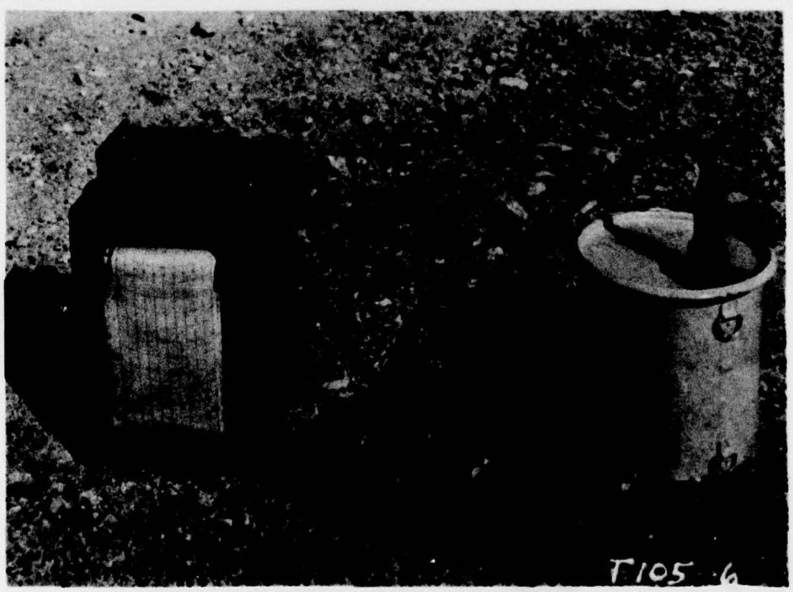

Fig. 1.3—Gamma monitoring station.

of business it was installed. The units were connected into normal 115-volt a-c power-line receptacles.

Warm Springs and Currant, Nev. (Stations 25 and 26, respectively), do not have a-c power service; they were provided with type TH-2-A gamma-ray monitors (Fig. 1.4). These units are completely self-contained and consist of a d-c powered monitor, graphic recorder, and dry-battery supply.

The stations were visited on an average of once every 15 days. The major operational interruptions were due to the intermittent quality of the power lines in the vicinity of the various towns. Few component failures were encountered.

The data on the graphic recorder tapes represented the history of the changes of activity. Since these monitoring sites were not in high fall-out zones, the tapes were collected during routine service visits. These tapes were analyzed to provide a knowledge of the alteration of the activity levels rather than to provide a warning mechanism.

Automatically responding telemeter units (Figs. 1.5 and 1.6) were attached to three stations for short periods during the early part of March. Although these devices provided no additional information for the Operation Teapot test period, the potentialities of the design philosophy were apparent. They require no special telephone company installation and can be called from any point in the continental United States without requiring special telephone lines.

1.4 DATA

Many stations indicated no change of background radiation reading throughout the test period. These stations were not in line with the specific wind trajectories during the shot period. The tape illustrated in Fig. 1.7 is typical of the data recorded by the responding stations. On March 12, Station 2, located at Mesquite, Nev., detected fall-out. The peak radiation reading of 0.33 mr/hr was measured at H+10 hr after fall-out for 80 min. The decay of the contaminated material reduced the level to 0.1 mr/hr in approximately 10 hr. The infinite dose was calculated using a $t^{-1.2}$ law. Information from all stations throughout the operating period is summarized in Table 1.1.

Table 1.2 contains information from stations not directly correlated in time. Because of extensive power-line failures in these towns, it was not possible to directly extrapolate the time at which fall-out started. However, it was possible to assign the fall-out to specific shots on the basis of the neighboring monitoring stations.

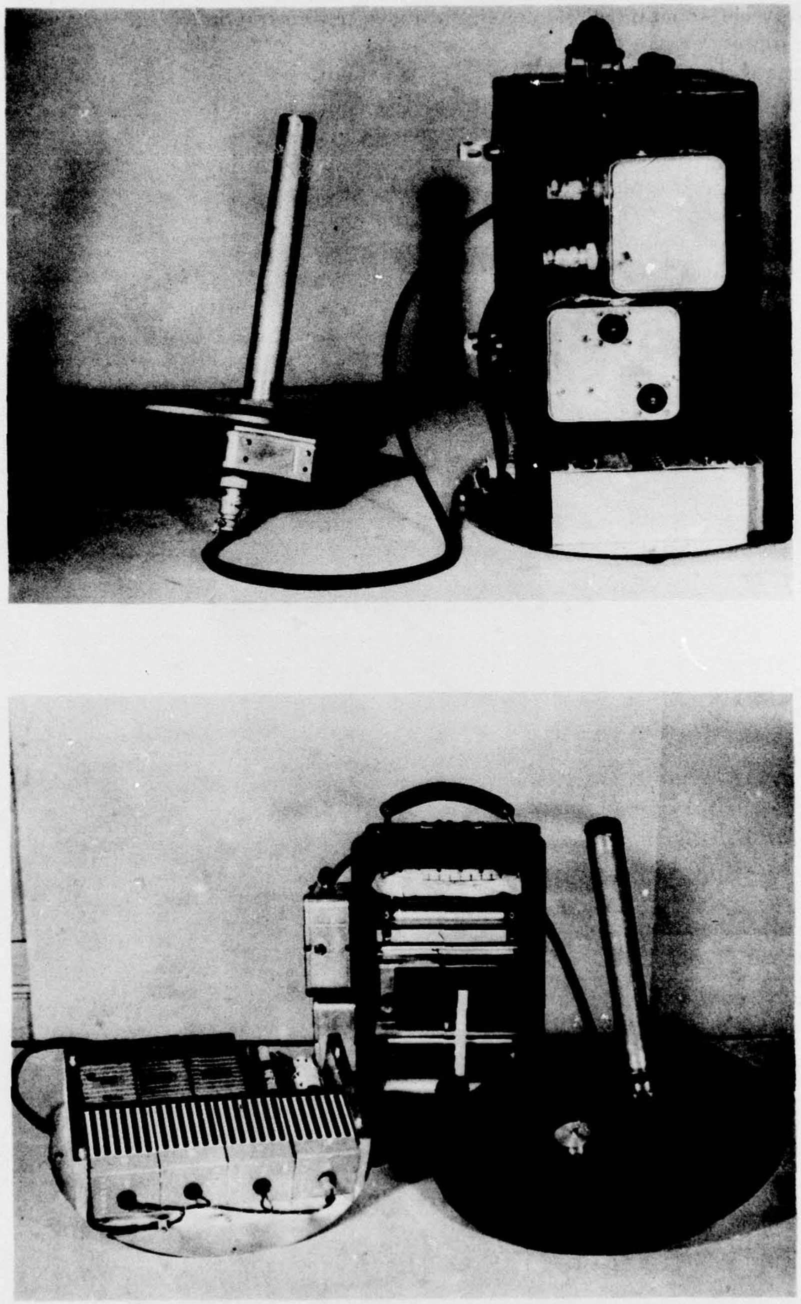

Fig. 1.4—Self-contained gamma monitor.

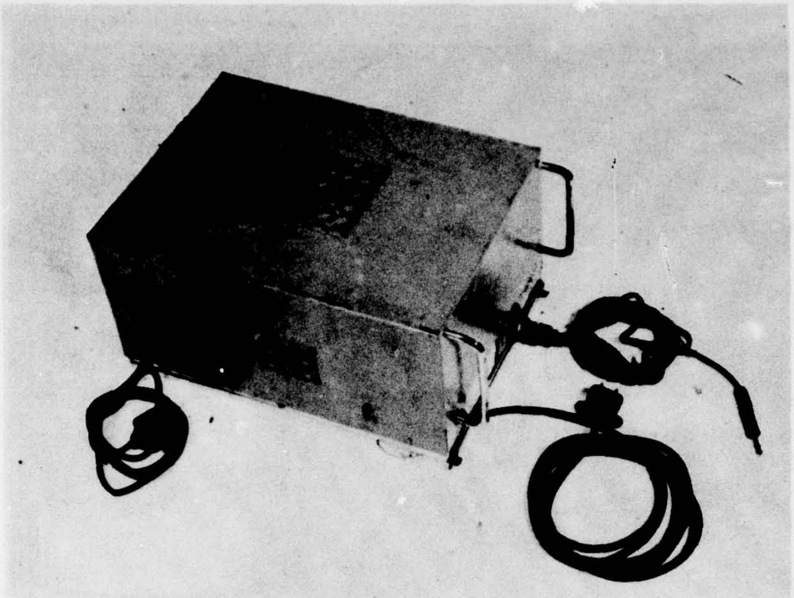

Fig. 1.5—Remote information unit.

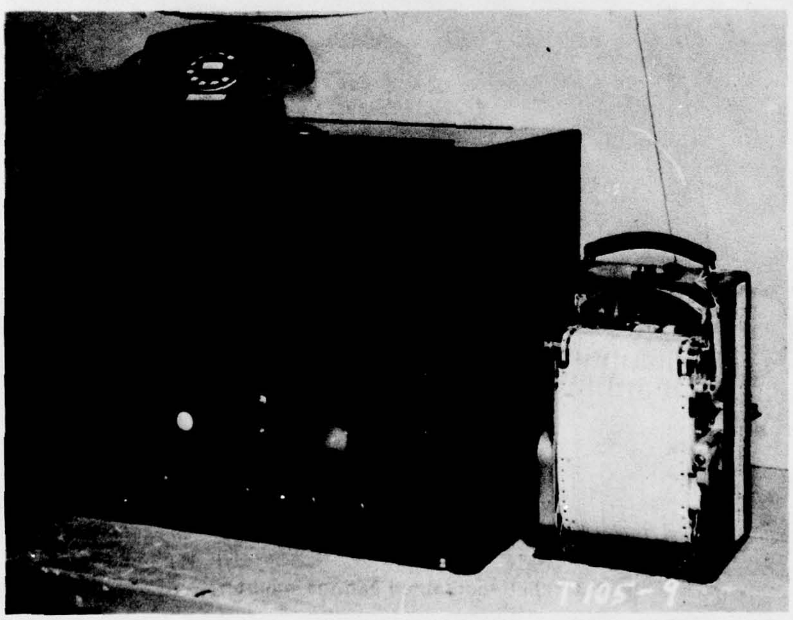

Fig. 1.6—Central station for "Telepulse" telemetering system.

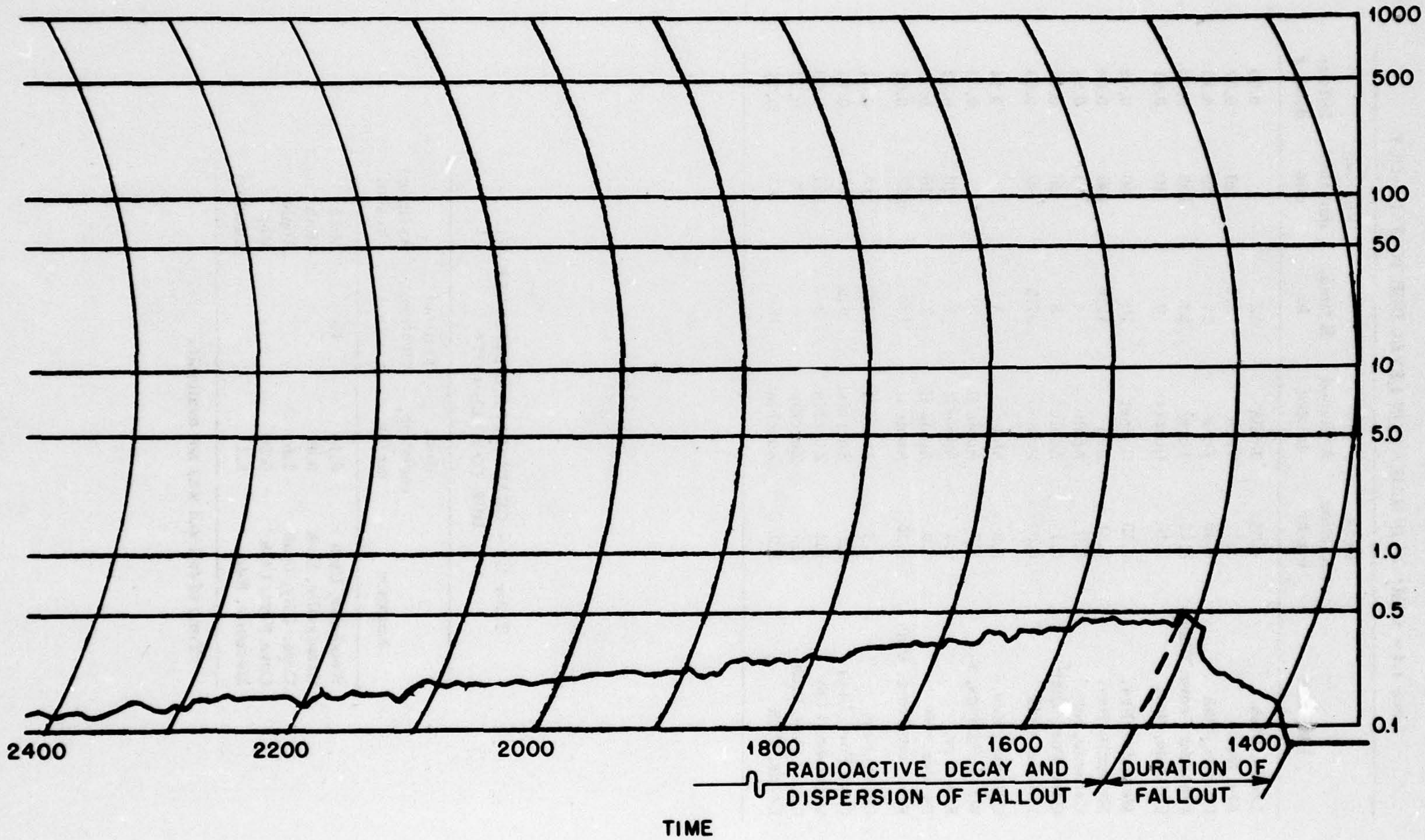

Fig. 1.7—Typical fall-out record for Station 2, Mesquite, Nev., Mar. 12, 1955.

Table 1.1—CHANGE IN RADIATION LEVEL DUE TO FALL-OUT

Location	Peak radiation, mr/hr	Assigned to shot	H time, hr	Fall-out duration, min	Infinite dose, r
Leeds, Utah	0.86	Tesla	12		0.09
Ely, Nev.	1.1	Turk	8.5	20	0.07
Payson, Utah	0.60	Turk	21	55	0.12
Pleasant Grove, Utah	0.12	Turk	23	105	0.03
Caliente, Nev.	0.16	Hornet	9	40	0.01
Mesquite, Nev.	0.33	Hornet	10	80	0.03
Mesquite, Nev.	0.31	Ess	13.5	180	0.04
Caliente, Nev.	9.0	Apple	4	20	0.24
Cove Fort, Utah	0.1	Apple	8	60	0.01
Payson, Utah	0.08	Post	37.5	90	0.03
Caliente, Nev.	5.3	Met	4		0.14
Warm Springs, Nev.	1.5	Apple II	3		0.03
Ely, Nev.	6.4	Apple II	7	20	0.33
Eureka, Nev.	0.6	Apple II	7	10	0.03
Pleasant Grove, Utah	0.35	Apple II	13	180	0.04
Oasis, Nev.	0.3	Apple II	15.5	10	0.04
Cove Fort, Utah	2.1	Zucchini	6.5	80	0.10
Gunnison, Utah	1.2	Zucchini	9	150	0.09
Cedar City, Utah	3.9	Zucchini		60	0.30
Leeds, Utah	2.2	Zucchini	18	60	0.34

Table 1.2—CHANGE IN RADIATION LEVEL DUE TO FALL-OUT*

Location	Peak radiation, mr/hr	Fall-out duration, min	Assigned to shot
Wendover, Utah	0.44	70	Moth
Grantsville, Utah	0.40		Moth
Cedar City, Utah	1.5		Apple
Cove Fort, Utah	0.50		Met
Mesquite, Nev.	2.1		Zucchini

*Time of fall-out was not available.

CHAPTER 2

DISCUSSION OF APPARATUS

2.1 GENERAL DISCUSSION

The equipment for a-c power-line operation consists of a HASL type TN-4-B gamma-ray monitor and, when needed, a Telephone Intelligence Transmission Station. Where a-c power is not available, a completely self-contained self-powered instrument is used (HASL type TN-2-A).

2.2 GAMMA-RAY MONITOR (HASL TYPE TN-4-B)

The gamma-ray monitor consists of two essential portions: (1) the detector and logarithmic conversion amplifier and (2) the power supply. The schematic diagram of this apparatus is shown in Fig. 2.1.

2.2.1 Detector and Logarithmic Conversion Amplifier

The detector element (Fig. 1.2) is a halogen-filled Geiger counter tube having a sensitive volume which was found to be satisfactory for the range 0.1 to 1000 mr/hr. The tube is critical to anode supply voltage when used as a d-c read-out device. However, this supply voltage is adequately stabilized with a standard corona voltage regulator (Raytheon Mfg. Co., Waltham, Mass., or Anton Electronic Laboratories, Brooklyn, N. Y.). The grid of the amplifier tube is connected directly to the Geiger-tube cathode. The amplifier tube is operated in a portion of its characteristic which has a logarithmic response.[1] Circuit compensation is provided so that the plate current reading can be offset toward zero, thus providing full-scale utilization for readings. The bias potentiometer provides a current bias which maintains the logarithmic character of the response down to a minimum plate current reading.

2.2.2 Power Supply

Because of the large voltage variation encountered in rural installations, the unit was designed to operate from 55 to 135 volts ac. A study of the characteristics of the lines available revealed that the frequency did not drift in a large measure. It was possible to use a Sola Electric Co. magnetic regulator transformer for the plate and filament supply. Filament-current stabilization was achieved with an Amperite Mfg. Co. regulator. This is a standard iron-wire barretter lamp which has a variable voltage vs constant current characteristic. The current characteristic was, of course, matched to the filament-current requirement for the amplifier tube. Seven hundred volts for the Geiger tube was supplied by a selenium rectifier voltage-doubler array. Although the power supply is able to provide about 1 ma at 900 volts, unregulated, the corona voltage regulator maintains the voltage at the desired 700-volt point.

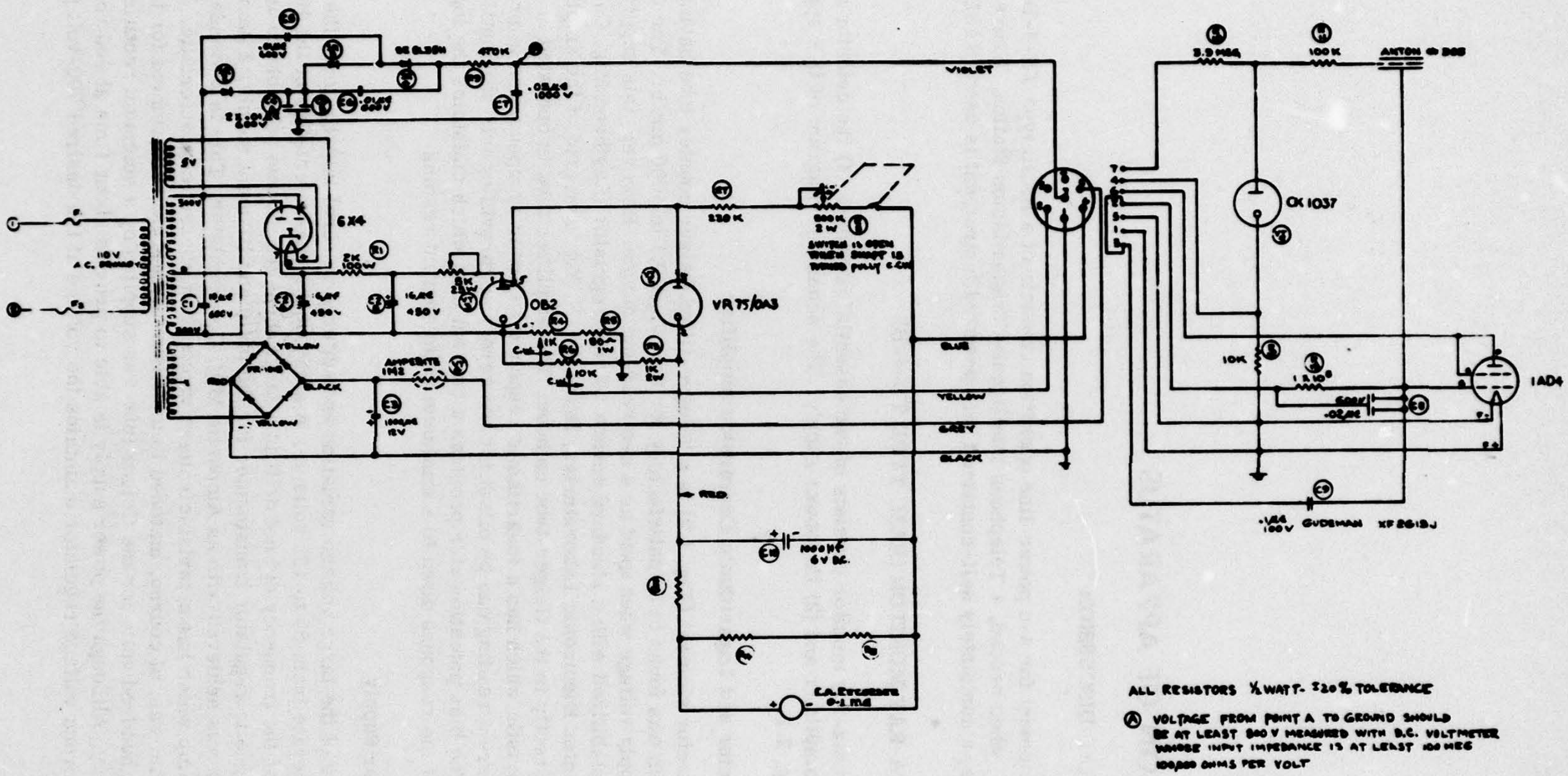

Fig. 2.1—Schematic diagram of gamma-ray monitor.

2.2.3 Hermetic Seals

The monitor and power supply are mounted in a type AN8029-27 military shipment can, which has a locking-ring arrangement for clamping the cover. The cover is fitted with a gasket, and a good mechanical seal is made by tightening the fastening screw of the clamp ring.

All electrical circuits were brought through hermetic fittings. The Joy Manufacturing Company connector, which is in the form of a cork type of seal, was used and found to withstand total immersion. The environmental tests showed that no moisture intrusion was detected.

2.2.4 Temperature Sensitivity

The unit was tested in the laboratory for temperature sensitivity. The range of the test facility was from +10 to +140°F. The reading did not vary with temperature within this region.

2.2.5 Shock Tests

The unit was successfully put through a vibrational test in three planes. The utility of this type of procedure was demonstrated by the fact that there was no mechanical field failure due to shock during transportation. All units arrived at their destination in good shape and required no mechanical rework.

2.3 SELF-POWERED GAMMA-RAY MONITOR (HASL TYPE TN-2-A)

The self-powered gamma-ray monitor is a completely self-contained self-powered unit with an internal recorder. To obtain long battery life, the unit measures the radiation level for 5 min of each hour. The radiation from fall-out persists for many hours and often for days; thus more frequent intervals are not required. This monitor consists of three sections, each of which performs a separate function:

1. The detector and logarithmic conversion amplifier.
2. The timer and recorder drive.
3. The battery supply.

The schematic diagram of this equipment is shown in Fig. 2.2.

2.3.1 Detector and Logarithmic Conversion Amplifier

The detector and logarithmic conversion circuit are based on the same design concept as that of the TN-4-B monitor (Sec. 2.2.1). However, a different tube selection has been made which permits operation over a different range of radiation levels and minimizes power requirements. The detector, a Geiger tube, has a sensitivity of 0.005 to 100 mr/hr. The amplifier tube type was selected both for logarithmic conversion characteristics and for low filament power drain.

2.3.2 Timer and Recorder Drive

An electrically operated clock mechanism with negligible power drain provides the starting impulse to a relay each hour. The relay starts the recorder drive timer. This drive locks itself on, activates the amplifier circuit, and advances the recorder chart. The drive timer is mounted on the side of a graphic recorder (Esterline-Angus, Indianapolis, Ind., model AW, without drive motor) and is directly linked to the paper drive. One revolution of the drive timer advances the recorder chart 3/4 in. After a revolution, which takes 5 min, is completed, the drive timer shuts itself and the detector circuit off. This cycle is repeated every hour.

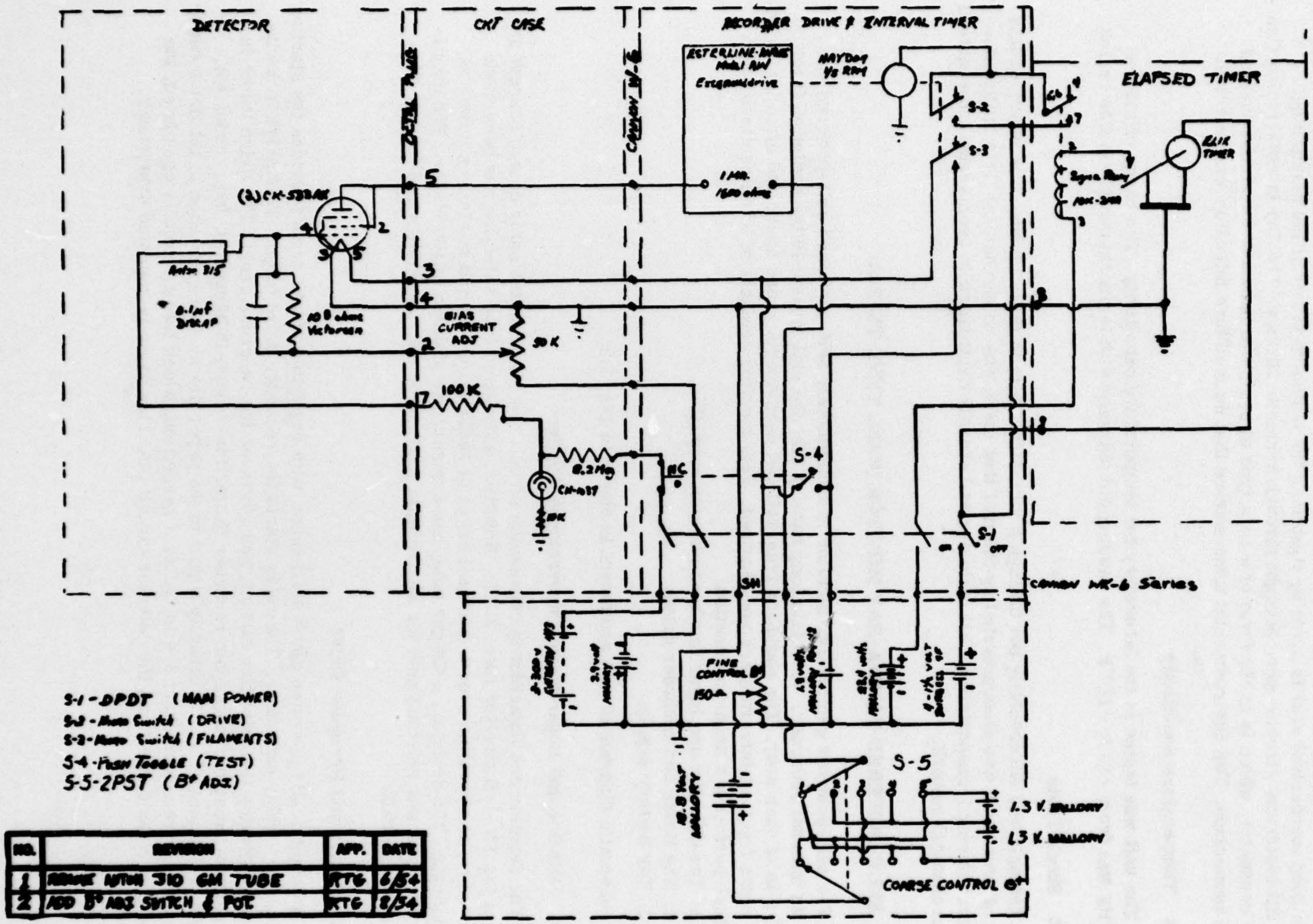

Fig. 2.2—Schematic diagram of self-powered gamma-ray monitor.

2.3.3 Battery Supply

The power supply is composed of batteries selected for minimum weight and size and for the required life characteristics. All critical voltages are provided by mercury type cells with the exception of the Geiger-tube high voltage, which is stabilized by a corona voltage regulator. The amplifier B plus may be varied continuously from 14.8 to 21.5 volts to control the reading sensitivity.

Owing to the 5-min on 55-min off cycle, the average power consumption is small. During the off period only the interval timer, bias supply, and high voltage remain on since they consume negligible amounts of power. The minimum battery life is three months.

2.3.4 Hermetic Seals

The complete unit, including the recorder, is housed in a commercial 12-gal container (Inland Steel Co., Chicago, Ill., No. 1282), which has a locking-ring and gasket assembly for sealing. The detector probe is brought out of the top of the can through a gland which incorporates an O-ring seal. During shipment this probe is removed and stored inside the container on the clamps provided on the recorder.

These units were used both during the Operation Castle tests and throughout Operation Teapot. Thus the instruments have been fully tested in the field under severe environmental conditions: salt corrosion and heavy rain in the Pacific and snow and heat in Nevada.

2.4 "TELEPULSE" TELEMETERING SYSTEM

An information station converts the reading on the gamma-ray monitor recorder to a pulsed-signal train. The number of pulses in the train is proportional to the indicated radiation reading. The information station is connected into standard telephone toll facilities through a plug-in telephone hand set. When called, it answers the phone, then transmits the monitor reading in pulse train form for a period of 2 min, and hangs up. If desired, the central station may lock on the remote unit so that it will continue to send readings until released.

The central station is also connected into standard toll facilities through a plug-in telephone hand set and may be used to call any of the remotely located information units. It contains the necessary circuits for decoding the pulse train and presenting the information of a graphic recorder.

2.4.1 Remote Information Unit

The information unit produces between 5 and 90 pulses for a corresponding recorder reading from 0 to 1.0 ma. These pulses are sent at a rate of 120 pulses/sec, and the train is repeated once a second.

The converter section transforms the d-c voltage on the recorder to pulses. These, when fed into the comparator, are again transformed from a series of pulses, whose amplitude is proportional to the input signal, into a train of pulses whose number per train cycle is proportional to the input d-c voltage. A coupling unit is connected to the telephone line and answers this line when signaled by the bell circuit. The central station can transmit a 2400-cycle note which, at the remote location, passes through narrow band tuned filters and permits the hang-up to be remotely controlled. When the tone is removed, the information station releases the telephone line until called again. If the tone is not sent, the information station automatically hangs up after 2 min.

A power supply section provides a source of stabilized voltages for the unit. It is connected to a 115-volt 60-cycle power line.

2.4.2 Central Station

The central station is connected between a telephone hand set and the telephone line. Plug-in telephone stations were used. The central station has controls for three operators. After the call is placed with a hand set, a "read" button activates the signal receiver and disconnects the hand set from the line. The signal receiver discriminates against noise and converts each signal pulse to constant size. The pulse train locks on a pulse counter for a period equal to each cycle. At the completion of each cycle the pulse counter transfers its reading to a graphic recorder. After 3 min the remote station automatically hangs up. However, the "lock-on" button at the central station may be used to inhibit the hang-up circuit until the release button is used. The release button reconnects the hand set in preparation for calls to the next stations.

REFERENCE

1. H. D. LeVine, Logarithmic D-C Ratemeters for Scintillation Counters, Nucleonics, 12(2): 36-39 (1954).

CHAPTER 3

TEST RESULTS

3.1 ANALYSIS OF INFORMATION

Figure 3.1 is a histogram representation of the dosage at the various stations during this period. It is based on infinite time dose in accordance with the standard procedure adopted at the Nevada Test Site. Although a great deal of work could be done on analyzing the data for information on time of the arrival, rate of deposition, etc., the character of the project does not appear to warrant an intensive mathematical interpretation of the data, which were designed to be documentary.

The unit reads gamma dose rate up to 1000 mr/hr. This is, of course, more than adequate for all normal off-site monitoring operations. However, in close-in work, higher radiation flux may be deduced. During Operation Castle[1] the Rongelap monitor went off scale from the March 1 shot. By extrapolating the curve on the rise and fall and by introducing the necessary decay data, it was possible to reconstruct the maximum exposure figure. These new data could be subjected to this type of interpretation had there been readings above full scale.

3.2 CONCLUSIONS

A complete record of the radiation dose history in these areas has been compiled. In addition, if there had been fall-out problems, the equipment would not only have determined the condition but would have had sufficient precision to permit interpretation of the pertinent data.

According to the readings no area of those monitored had sufficient fall-out to require action.

3.3 RECOMMENDATIONS

The gamma-ray monitors fulfilled their design specifications. No failures were caused by environmental conditions, and, although only a minimum of servicing trips was possible, good coverage was maintained. To avoid loss of interpretable data due to timing interruptions, new chart drives will be obtained for future use. These will be spring driven with electrical windup so that during periods of no power the time will continue to be recorded.

If there were a reason to monitor many areas, equipment of this character would be useful. During test periods, in areas adjacent to the test site, this type of apparatus provides a simple means of obtaining data. During test periods, also, automatically responding telemeters have utility; the need for them must, of course, be predicated upon the necessity of having this type of radiation information promptly.

REFERENCE

1. A. J. Breslin and M. E. Cassidy, Radiation Debris from Operation Castle — Islands of the Mid Pacific, Report NYO-4623.

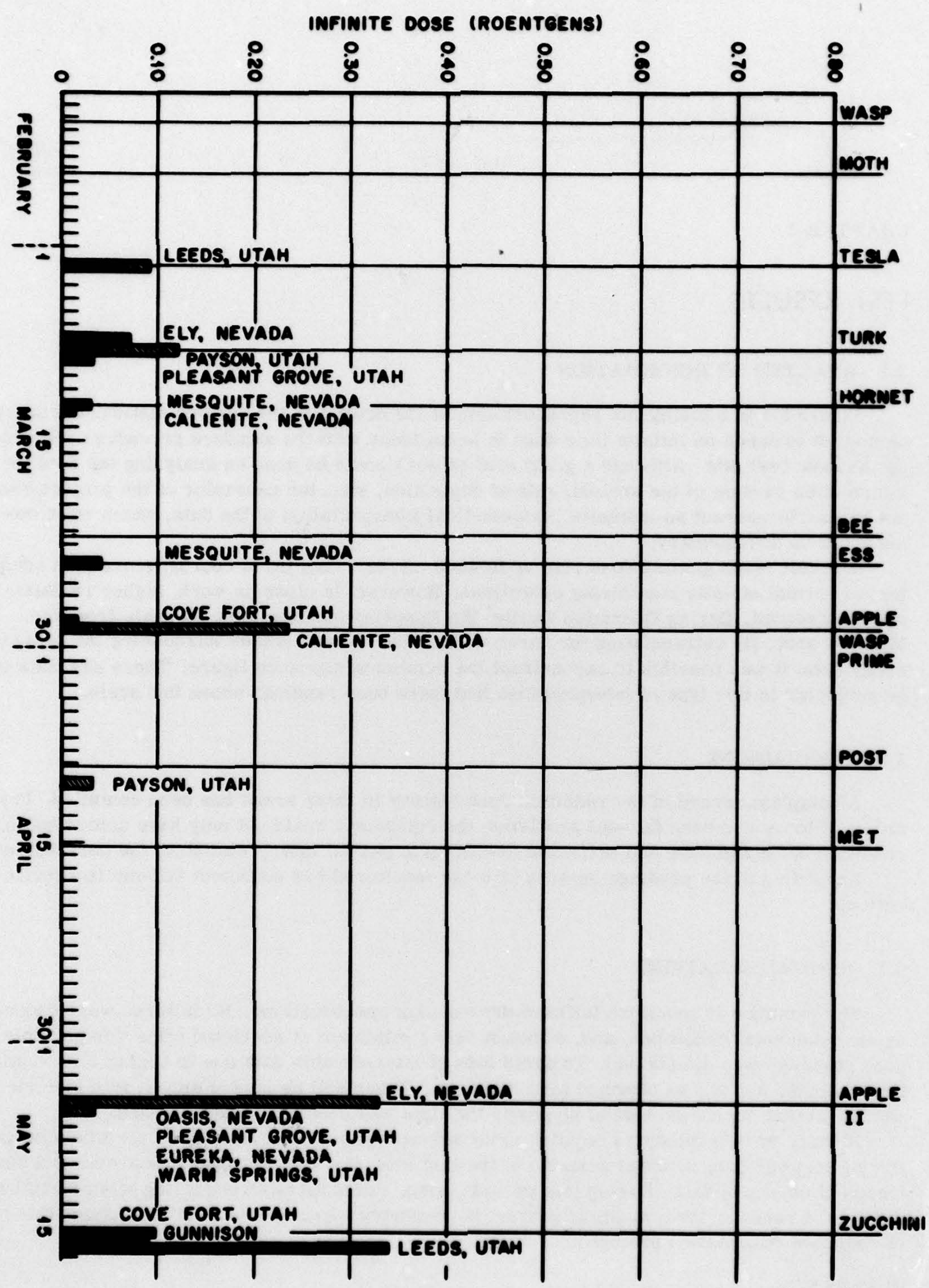

Fig. 3.1—Dosage at the various stations.